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ESD-TR-70-137

AD871747

THIRD QUARTERLY TECHNICAL REPORT
MONTANA LARGE APERTURE SEISMIC ARRAY

April 1970

AD NO. ___

DIRECTORATE OF PLANNING AND TECHNOLOGY
HQ ELECTRONIC SYSTEMS DIVISION (AFSC)
L. G. Hanscom Field, Bedford, Massachusetts 01730

Sponsored by: Advanced Research Projects Agency
Washington, D. C. 20301

ARPA Order No. 800

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(Prepared under Contract No. F19628-70-C-0010 by Philco-Ford Corporation, Communication and Technical Services Division, 214 North 30th, Billings, Montana 59101.)

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FOREWORD

This research is supported by the Advanced Research Projects Agency. The Electronic Systems Division technical project officer for Contract No. F19628-70-C-0010 is Lt. J. R. Todd (ESLC). This report covers the period from 1 January 1970 through 30 March 1970.

This technical report has been reviewed and is approved.

James R. Todd
Lt., USAF
Chief, Seismic Array Program Office
Communications Division
Directorate of Planning and Technology

ABSTRACT

This report concerns the technical activity associated with the operation and maintenance of the Montana Large Aperture Seismic Array (LASA) for the period January - March, 1970. A planned study of the short-period seismic channel tolerances is presented. A new procedure for characterizing array equipment failures is described along with changes to the EDP maintenance documentation system. Recent calibration data for the ESSA microbarograph array are given. Release of a weather bulletin via phone line interface between the LASA Data Center and the Billings Weather Bureau is described. Description of a long-period seismometer cabling and free-period adjustment improvement modification is included. A short-period sensor field test and RA-5 amplifier rehabilitation program in progress is detailed. The LDC computer and array operation statistics are provided.

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ACRONYMS

ESSA	Environmental Science Services Administration
LASA	Large Aperture Seismic Array
LDC	LASA Data Center
LMC	LASA Maintenance Center
LP	Long Period
PMEL	Precision Measurement and Equipment Laboratory
SAAC	Seismic Array Analysis Center
SEM	Subarray Electronic Module
SP	Short Period
WHV	Well Head Vault
WOSR	Work Order Search and Retrieval

SECTION I

INTRODUCTION

The work reported in this third quarterly report was performed under the Montana Large Aperture Seismic Array Contract Number F19628-70-C-0010. The contract entails the provision of services, materials and facilities necessary to perform research effort, develop and improve, and to maintain and operate the LASA Facility Montana Large Aperture Seismic Array (LASA) located in the state of Montana. The specific purpose of the contract is identified in the following tasks:

A. Operate and maintain the LASA data acquisition equipment by:

(1) Utilizing the PDP-7 computer with its peripherals at the LASA Data Center (LDC) to record data in the prescribed format in the back-up mode to the on-line real-time communications linking the LDC to the Seismic Array Analysis Center (SAAC) in Washington, D.C. This will provide 168 hours per week back-up recording when the on-line computer (IBM 360/Model 44) on the transcontinental data link malfunctions or requires maintenance.

(2) Providing and maintaining a tape library at the LDC to retain all recorded tapes.

(3) Utilizing the maintenance, monitoring, and control facilities at the LDC for checks of array performance and performing liaison with power and telephone companies.

(4) Providing the necessary computer operators 168 hours per week for the on-line transcontinental data link computer, IBM 360/Model 44.

B. Provide, operate and maintain specially equipped vehicles for field maintenance and one vehicle for administrative purposes.

C. Provide physical facilities by lease to house the LDC, Billings, and the LMC, Miles City, Montana, to include all necessary related support as janitorial services, necessary parking space and building maintenance.

D. Provide all necessary general administrative support such as, but not limited to: (1) utilities, (2) telephones, (3) postage, (4) TWX, (5) office supplies, (6) freight charges, (7) stockrooms, and (8) liaison with the United States Department of Interior, Bureau of Land Management, insofar as leasing of public lands near the LASA, Montana, is concerned.

E. Provide maintenance of leases, easements, rights-of-way, agreements, and authorizations for access to 525 LASA field sites.

F. Provide for continued power and telephone utilities for the LASA subarrays.

G. Provide property control in support of all material residual from prior related contracts as well as the applicable Facilities Contract Number F19628-68-C-0298.

All effort in support of these tasks that occurred during this reporting period is presented in the subsequent sections of this report.

Listed at the end of the report are references which are applicable to the detailed effort presented.

SECTION II

OPERATION

2.1 Data Center Computer

The IBM/360 computer operated on-line to the Seismic Array Analysis Center (SAAC) 92.0% of this third quarter. This is a decrease from the previous two quarters due primarily to an increased amount of scheduled outages for equipment sales changes and program development (20.7 hours). Thirty-nine hours, or 1.8% of the outage time, were due to the 50 kilobaud phone line service interruptions. The IBM/360 computer utilization statistics are shown in Table I.

TABLE I

SYSTEM/360 MODEL 44 COMPUTER UTILIZATION

OPERATION	ACCUMULATED TIME, HOURS			
	JAN.	FEB.	MARCH	TOTAL
On-line system program operation:				
Recording with WAPS	686.5	615.8	685.5	1987.8
Running at LASA only	10.1	9.5	5.8	25.4
Downtime:				
Scheduled maintenance	22.5	18.0	5.9	46.4
Corrective maintenance	8.6	0	0	8.6
Waiting for maintenance	10.9	0	0	10.9
Program halts and loops	1.6	1.2	0	2.8
Idle time	0	1.0	17.3	18.3
Running diagnostics	0	0	0	0
Program development	0	16.7	4.0	20.7
Shutdown, other than computer equipment inoperative	3.8	9.8	25.5	39.1
TOTALS	744.0	672.0	744.0	2160.0

The operational and recording requirements of the data center's PDP-7 computer resulted in back-up mode operation on 78 occasions covering an accumulated time period of 179.9 hours. This operation produced 1341 magnetic tapes recorded by the computer on 51 different days. The PDP-7 computer utilization statistics are shown in Table II.

TABLE II

PDP-7 COMPUTER UTILIZATION

OPERATION	ACCUMULATED TIME, HOURS			
	JAN.	FEB.	MARCH	TOTAL
On-line system program operation, Back-Up recording	58.5	58.7	62.7	179.9
On-line calibration recording and system maintenance testing	31.9	23.8		55.7
Seismic data tape duplication and/or verification				
General use including:				
Program development	40.1	32.0	91.4	163.5
Running utility programs	51.1	31.2	59.8	142.1
Computer downtime including:				
Scheduled maintenance	6.5	1.5		8.0
Corrective maintenance				
Shutdown, computer equipment inoperative				
System program stopped during cal-outs and program traps		0.1	0.2	0.3
Computer idle time	555.5	524.7	523.6	1603.8
Training				
Diagnostic programs and testing	0.4		6.1	6.5
Shutdown, other than computer equipment inoperative			0.2	0.2
TOTAL	744.0	672.0	744.0	2160.0

2.2 Data Center Library

The operation of the LDC tape and film library for this quarter consisted of (1) saving 1341 high rate PDP-7 computer tapes recorded during periods of back-up system operation, and (2) distributing four reels of high rate tape to IBM-SAAC. As of the end of March 1970, tapes covering back-up operation periods from 10 October 1969 to 31 March 1970 were available for distribution.

2.3 Array Control

The array control function at the LDC consists of (1) array and data center equipment performance monitoring and test, (2) interface with telephone company personnel regarding telephone equipment performance, and (3) generating and maintaining appropriate records to document the technical activities associated with array maintenance and operation.

2.3.1 Data Center Equipment

During this third quarterly period, maintenance and failures in the IBM/360 and wideband data link systems resulted in no data being transmitted to SAAC from the Montana array for a total accumulated time period of 107.8 hours. This is an increase from the time periods of 51.0 and 68.7 hours for the first and second quarters respectively. Additionally, whenever certain WAPS equipment requires maintenance, no real-time data is transmitted from the LDC; during this quarter 25.4 hours of back-up operation occurred for this reason. This continues the decreasing trend of 60.8 and 37.1 hours for this operational parameter.

2.3.2 Array Equipment

For the purpose of array control, the present configuration of array equipment has been divided into six groupings. These groups include (1) the short-period seismic sensors, (2) the long-period seismic sensors, (3) the microbarograph sensors, (4) the meteorological sensors, (5) the subarray electronics and control equipment, and (6) the communication circuits. The distribution of the equipment sensor groups differs among the 21 subarrays. Short-period seismic sensors are installed at all subarrays; long-period sensors are at all subarrays except in the B-rings; microbarograph sensors are at all subarrays except E3; and meteorological sensors are at eight subarrays only. Reference 2 contains a detailed listing of the array equipment configuration.

Operation and maintenance of the array equipment requires that the data be interrupted at various time periods, during which time normal or reliable data may not be available to the LASA data user. The reasons established for data interruptions are: (1) maintenance, either being performed or

initiated, (2) subarray equipment failure in which no maintenance has been initiated, (3) telephone company(s) performing tests on the communication circuits, (4) telephone company(s) communication link not functioning, (5) power outage at the subarray, or (6) special data center testing. In the event any of these situations occur, a notation is made in the data interruption log relating to the data affected and the time period. For the case of short-period and long-period data interruptions, SAAC is alerted via the System 360 typewriter. The durations of subarray data interruptions recorded during this quarter are listed in Table III.

The equipment groups connected to the data center via the telemetered communications channels have certain known responses to telemetry commands whereby the condition of the various equipments may be determined. When these responses exceed the tolerances established for a particular channel, an equipment failure is reported. The improper channel responses which require maintenance action from the LMC are recorded on a work order. Those which can be corrected from the LDC maintenance console, such as the long-period seismometer mass position and free-period adjustments, are logged on a LP system check sheet. The normal seismic channel responses to sinusoidal calibrations are shown in Table IV.

Table V indicates the incidence of defective channels detected by checks performed from the LDC for the six equipment groupings mentioned at the beginning of this section. The large incidence of defective LP channels results from 188 out-of-tolerance measurements of the long-period seismometer's mass position and free period; mass position is centered to within ±2mm and natural frequency maintained within 20±1 second.

2.3.3 Microbarograph Equipment Calibrations

Tests and calibrations have been performed this quarter on the thirteen ESSA microbarographs installed in four inner-rings of the LASA. The results of effort are shown in Figure 2.1. This figure, a sample of the microbarograph array calibration report being distributed from the LDC, identifies each microbarograph channel and shows the channel sensitivities, full scale values, 3 dB response times, the peak-to-peak low frequency system noise level, and the date and time.

The channel sensitivities and full scale values for the ESSA microbarographs (response code C125) are determined from a single, low-amplitude (about 8% of full scale), sinusoidal, pressure-signal input as produced from an ESSA motor-driven bellows-type calibrator. The sinusoidal calibration signals were recorded at the LDC Maintenance Display Console and computer processed and recorded either at SAAC or by the PDP-7 computer at the LDC. Immediately prior to this calibration the sensor acoustical input was plugged and the system noise recorded and computer processed for approximately 10 minutes.

TABLE III

SUBARRAY DATA INTERRUPTION OUTAGES

SUB-ARRAY	DATA	TOTAL TIME DURATION OF DATA INTERRUPTIONS IN HRS.			
		JANUARY	FEBRUARY	MARCH	TOTAL
AO	SP	1.1	1.6	3.1	5.8
	LP	1.1	1.3	3.1	5.5
	μbaro	1.1	1.3	3.1	5.5
	Meteor	1.1	1.3	3.1	5.5
	Telco	.2	0	.8	1.0
B1	SP	.1	.4	0	.5
	μbaro	.1	0	0	.1
	Telco	0	0	.1	.1
B2	SP	0	.4	2.6	3.0
	μbaro	0	0	2.6	2.6
	Telco	0	0	.1	.1
B3	SP	0	.4	0	.4
	μbaro	0	0	0	0
	Telco	0	0	.1	.1
B4	SP	0	.4	0	.4
	μbaro	0	0	0	0
	Telco	.9	.3	.7	1.9
C1	SP	0	.4	0	.4
	LP	0	0	0	0
	μbaro	0	0	0	0
	Telco	0	.3	.7	1.0
C2	SP	0	17.4	2.7	20.1
	LP	0	17.1	2.7	19.8
	μbaro	0	17.1	2.7	19.8
	Telco	.1	0	.1	.2
C3	SP	0	.4	0	.4
	LP	0	0	0	0
	μbaro	0	0	0	0
	Telco	0	0	.9	.9

TABLE III (CONTINUED)

SUBARRAY DATA INTERRUPTION OUTAGES

SUB-ARRAY	DATA	TOTAL TIME DURATION OF DATA INTERRUPTIONS IN HRS.			
		JANUARY	FEBRUARY	MARCH	TOTAL
C4	SP	0	.4	0	.4
	LP	0	0	27.1	27.1
	μbaro	0	0	0	0
	Telco	0	0	.1	.1
D1	SP	0	.4	0	.4
	LP	0	0	0	0
	μbaro	0	0	0	0
	Telco	16.5	0	7.7	24.2
D2	SP	2.2	1.7	6.8	10.7
	LP	2.2	105.2	96.4	203.8
	μbaro	2.2	1.3	6.8	10.3
	Telco	0	1.1	1.9	3.0
D3	SP	0	.4	3.9	4.3
	LP	0	0	3.9	3.9
	μbaro	0	0	3.9	3.9
	Telco	0	0	.9	.9
D4	SP	0	.4	0	.4
	LP	0	0	0	0
	μbaro	0	0	0	0
	Telco	0	0	1.3	1.3
E1	SP	1.1	.4	0	1.5
	LP	1.1	0	0	1.1
	μbaro	1.1	0	0	1.1
	Meteor	1.1	0	0	1.1
	Telco	0	0	1.6	1.6
E2	SP	.2	.4	0	.6
	LP	.2	0	0	.2
	μbaro	.2	0	0	.2
	Meteor	.2	0	0	.2
	Telco	0	0	.1	.1

TABLE III (CONCLUDED)

SUBARRAY DATA INTERRUPTION OUTAGES

SUB-ARRAY	DATA	TOTAL TIME DURATION OF DATA INTERRUPTIONS IN HRS.			
		JANUARY	FEBRUARY	MARCH	TOTAL
E3	SP	0	.4	0	.4
	LP	0	0	0	0
	Telco	0	0	.1	.1
E4	SP	.2	.4	0	.6
	LP	.2	0	0	.2
	μbaro	.2	0	0	.2
	Meteor	.2	0	0	.2
	Telco	0	0	.8	.8
F1	SP	.2	.4	6.7	7.3
	LP	.2	0	6.7	6.9
	μbaro	.2	0	6.7	6.9
	Meteor	.2	0	6.7	6.9
	Telco	2.1	3.1	5.3	10.5
F2	SP	3.3	.4	26.9	30.6
	LP	3.3	0	72.7	76.0
	μbaro	3.3	0	26.9	30.2
	Meteor	3.3	0	26.9	30.2
	Telco	0	.1	.1	.2
F3	SP	.1	.4	0	.5
	LP	.1	0	0	.1
	μbaro	.1	0	0	.1
	Meteor	.1	0	0	.1
	Telco	0	0	.1	.1
F4	SP	.2	.4	0	.6
	LP	.2	0	0	.2
	μbaro	.2	0	0	.2
	Meteor	.2	0	0	.2
	Telco	0	8.0	.7	8.7

TABLE IV

LASA DATA CHANNEL ALLOWABLE TOLERANCES

Channel	Tel. Com. TC-	Channal Number	Chart Recorder Allowable Response Range*	
			Volts (p-p)	Nominal Voltage (p-p)
Short-Period Sensor	6	Selected	6.4 to 11.0	7.91
Attenuated SP Sensor	6	22	.202 to .348	.25
Long-Period Sensor	20	26,27,28	5.2 to 8.6	7.0
C2-Attenuated LP Sensor	20	26,27,28	1.81 to 3.00	2.44

*Corrected for calibration oscillator variations.

TABLE V

INCIDENCE OF DEFECTIVE SUBARRAY CHANNELS/EQUIPMENT

SUBARRAY	CHANNELS				EQUIPMENT	
	SP	LP	μBARO	METEOR	SEM	STANDBY POWER
AO	0	20	0	0	0	0
B1	1	-	0	-	0	0
B2	3	-	1	-	0	0
B3	2	-	1	-	0	0
B4	1	-	0	-	0	0
C1	0	11	0	-	0	0
C2	1	12	0	-	0	0
C3	0	19	0	-	0	0
C4	0	10	1	-	C	0
D1	3	14	0	-	0	0
D2	3	15	1	-	1	0
D3	0	11	0	-	0	0
D4	3	6	0	-	1	0
E1	1	7	0	0	0	0
E2	4	7	0	0	0	C
E3	1	9	-	-	0	0
E4	1	11	0	0	0	0
F1	2	15	0	0	0	0
F2	0	21	0	0	0	0
F3	2	16	0	0	0	0
F4	0	3	0	0	0	0
TOTALS	28	207	4	0	2	0

IISPS LR CHANNEL	SUBARRAY	SYSTEM NUMBER	RESPONSE CODE	CHANNEL SENSITIVITY (mv/μbar)	CHANNEL FULL SCALE (μbar) p-p	UPPER RESPONSE TIME (SEC)	LOWER RESPONSE TIME (SEC)	SYSTEM NOISE LEVEL (mv) p-p	DATE AND GMT TIME OF CALIBRATION
L79	F3	L-109	A250	56	250	4.3	67	<1.0	1-10-68
L80	F4	L-111	A250	56	250	4.3	67	<1.0	1-2-69
L81	AO	L-103	A250	56	250	4.3	67	<1.0	1-10-68
L82	E4	L-101	A250	56	250	4.3	67	<1.0	1-17-68
L83	E1	L-107	A250	56	250	4.3	67	<1.0	2-7-68
L84	F1	L-106	A250	56	250	4.3	67	<1.0	2-28-68
L85	E2	L-104	A250	56	250	4.3	67	<1.0	1-19-68
L86	F2	L-105	A250	56	250	4.3	67	<1.0	3-12-69
L87	B1	E-5	C125	114.3	122	0.29	47.6	40	2058-2017 3-13-70
L88	AO	E-11	C125	104	135	0.29	47.6	-	2131-2154 4-1-70
L89	C4	E-8	C125	125.3	112	0.29	47.6	25	1957-2008 3-16-70
L90	B4	E-12	C125	175.7	80	0.29	47.6	<1.0	2213-2220 3-13-70
L91	C1	E-4	C125	132.8	105	0.29	47.6	30	2014-2019 3-13-70
L92	C2	E-3	C125	147.5	95	0.29	47.6	20	1848-1858 3-13-70
L93	B2	E-10	C125	116	121	0.29	47.6	110	1639-1649 4-2-70
L94	C3	E-9	C125	31.7	442	0.29	47.6	20	2156-2205 3-16-70

Figure 2.1 Microbarograph Array Calibrations

IISPS LR CHANNEL	SUBARRAY	SYSTEM NUMBER	RESPONSE CODE	CHANNEL SENSITIVITY (mv/μbar)	CHANNEL FULL SCALE (μbar) p-p	UPPER RESPONSE TIME (SEC)	LOWER RESPONSE TIME (SEC)	SYSTEM NOISE LEVEL (mv) p-p	DATE AND GMT TIME OF CALIBRATION
L95	D3	E-13	C125	111	126	0.29	47.6	40	1649-1659 4-3-70
L96	D4	E-7	C125	97.9	143	0.29	47.6	15	1803-1820 4-2-70
L97	D1	E-2	C125	37.6	373	0.29	47.6	<1.0	1753-1803 3-16-70
L98	D2	E-1	C125	105	133	0.29	47.6	30	1708-1719 3-23-70
L103	AO	L-110	B1667	8.4	1667	4.3	1000	<1.0	5-15-68
L104	B3	E-6	C125	105.3	133	0.29	47.6	615	2054-2103 3-16-70

Figure 2.1 Microbarograph Array Calibrations (Concluded)

Since in the present ESSA microbarograph system, the sensitivities are not adjustable and therefore variations occur from system to system depending upon the characteristic differences in the acoustic networks, diaphragms, and discriminators. Periodically, the tests will be repeated and the calibration report will be updated to reflect any sensitivity or response changes. These updated reports will be distributed to recognized microbarograph data users.

2.4 Integrity Control

2.4.1 Short-Period Seismic Channel Tolerances

A study effort is in progress at the LDC directed towards a better definition of the seismic channel allowable tolerances. Data from the weekly array calibration tests are being collected and analyzed. Presently, the standard short-period channels are being studied. The attenuated channels and the standard long-period channels are next planned for investigation to determine if the tolerances which are presently being used (as established during Lincoln Laboratory control of the array operation) can be narrowed to reduce the amount of scatter among the channel calibration responses. Detailed analysis of the different types of array channels is being completed during this study. This should assist in defining additional tolerances for other channel parameters, viz., dynamic range, linearity, etc. Preliminary results thus far indicate that the short-period, 1 Hz, channel-sensitivity tolerance of 16.2 to 27.8 mV/nm can be narrowed. The amount of allowable tolerance change which is determined to be reasonable will be reported following the completion of this study effort.

2.4.2 Equipment Failure Reporting

A new system for the reporting of array equipment failure statistics has been developed. Changes to the existing maintenance statistics collecting system were made to provide greater detail in the equipment failure information being generated. Equipment failures are now defined at the part level as opposed to the assembly level. A failure is an abnormality in a part of an assembly which controls the systems performance. An abnormality, a measurable and significant deviation from a standard, becomes a failure when some internal physical or electrical characteristic of the part exceeds the normal operating limits. To improve failure identification, failures are classified to accommodate the variety of different types of failures in the array equipment. Further, the classifications are based on equipment performance effects that can be readily observed and identified. The focal point for this identification is the LDC maintenance console where the system outputs can be measured. The failure classification codes are included on the work order form prepared by the maintenance technician and are as follows:

(1) system failure - a failure resulting in zero or no system output which prevents the system or equipment from performing its primary function.

(2) mode failure - a failure which results in no system output during one of several different modes of operation.

(3) limited failure - a failure resulting in a system output which is outside the allowable tolerance limits but permits degraded performance.

(4) latent failure - a failure which changes a system output either by an amount less than the allowable tolerance or from the nominal output when no tolerance limits have been established.

(5) temporary failure - a failure produced by an operating or environmental stress which results in no permanent physical damage.

2.4.3 WOSR System Changes

The LASA Work Order Search and Retrieval (WOSR) system has been changed to accommodate improvements, such as the equipment failure code described in paragraph 2.4.2 of this report. Figure 2.2 shows a sample of the Work Order Search and Retrieval output incorporating the changes. Reading from left to right, the first change is in the work order number (column 10-14). This entry starts with an "A," "B," or "C," followed by the last four digits of the work order number. The letter denotes the portion of the work order to which the line entry corresponds. The work order form is in three parts, permitting reports on three levels of array hardware maintenance. Normally, part 1 (entry A) begins with a system malfunction and ends with a defective equipment assembly report. Part 2 (entry B) is then initiated on the defective equipment assembly and identifies the subassembly containing the failed part or, if no subassembly is involved, it indicates the failed part itself. Part 3 (entry C) is the subassembly repair work order which indicates the failed part(s).

The next change is in the equipment name (column 22-27). The name codes have been expanded to reflect the three levels of hardware maintenance reporting permitted in this new system. Likewise, the subassembly (column 35), symptom (column 37), and action taken (column 39) codes have been modified to accommodate the new information to be handled by the system. Column 41 contains the failure type code previously discussed. In the work order status column (43), the letter "C" indicates the completion of the total repair cycle for each reported failure. For example, it is used after "A" work order numbers if "B" and "C" part numbers are not required, and after part "C" work order

numbers only if all parts have been used. If more than one part "C" work order is required to complete the repair effort, this code is added to the final part "C" entry when all other part "C's" have been completed.

```
MODE = Q
START DATE = 3/18/70.
STOP DATE = 3/31/70.
LOCATION(S) = LDC.
EQUIPMENT TYPE = .
SYMPTOM = .
ACTION = .
TYPE OF FAILURE = .
WO OPEN OR CLOSED = .
COUNT ONLY? (YES,NO)   N.
HISTORY? (YES,NO)  Y.
3 /24/70 B1395 LDC    MDC-1  1      3 D L   C REPLACED PINS  2EA.
3 /20/70 B1403 LDC    SYNCTL 609    6 Y Y   C PM
3 /20/70 B1403 LDC    SYNCTI 610    6 Y Y   C PM CHECK + RESET IF NEEDED
3 /23/70 B1394 LDC    CARDRE        0 G E 5 C ADJUST HOPPER SWITCH
3 /23/70 B1404 LDC    MISC          7 Y Y   C CLEAN AND LUBRICATE
3 /23/70 B1404 LDC    MISC          7 Y Y   C CLEAN AND LUBRICATE
3 /18/70 B1393 LDC    TAPEU  32     3 T J 5 C
3 /18/70 B1393 LDC    TAPEU  32     0 V L   C REPLACE DOOR AND SPRING
3 /18/70 B1392 LDC    TAPEU  19     3 S L 1 C REPLACE VAC MOTOR BRUSHES 2
3 /26/70 B1399 LDC    TAPEU  19     0 Y Y   C PM
3 /26/70 B1399 LDC    TAPEU  32     0 Y Y   C PM
3 /26/70 B1399 LDC    TAPEU  33     0 Y Y   C PM
3 /26/70 B1400 LDC    PWRSYS        4 Y Y   C PM
3 /23/70 B1401 LDC    CARDRE        0 Y Y   C PM
3 /23/70 B1402 LDC    TAPEU  19     0 Y Y   C PM
3 /23/70 B1402 LDC    TAPEU  32     0 Y Y   C PM
3 /23/70 B1402 LDC    TAPEU  33     0 Y Y   C PM
3 /30/70 B1396 LDC    MDC-1  1      3 C L 2 C REPLACED BATTERY 14200041
3 /27/70 B1421 LDC    SYNCTI        1 Y Y   C CHECK AND RESET HYPER CLOCK
3 /27/70 B1421 LDC    SYNCTL        1 Y Y   C CHECK AND RESET HYPER CLOCK
LDC   COUNT =      20
TOTAL COUNT =      20
```

Figure 2.2 Sample Work Order Search and Retrieval Printout

SECTION III

MAINTENANCE

3.1 Data Center

3.1.1 General Discussion

Equipment maintenance activity at the LDC is summarized by the number of repair and preventive maintenance actions shown in Table VI. The entries for the IBM System 360/Model 44 computer were obtained from the GSA and IBM maintenance logs. IBM provides maintenance for this leased computer. The PDP-7 computer tape units were again the major contributor to the data center maintenance requirement primarily due to its electromechanical nature; however, this quarter the number of tape unit maintenance actions decreased by one-half from 44 to 22.

No major failures occurred in the LDC equipment during this period. The reported incidence of maintenance console repair actions results primarily from normal battery usage in the chart recorder zero-suppression unit. The increase in preventive maintenance actions results from continued development of the program established at the beginning of this contract.

3.1.2 Weather Bureau/LASA Interface

A hardware interface has been established between the Billings Weather Bureau office and the LDC PDP-7 computer to provide weather data from the eight LASA weather stations (see reference 1) for weather bureau use in forecasting the Eastern Montana weather. Figure 3.1 shows the interface and connections made to the data center computer. Following logic level conversion and inversion of the computer output, connection is made to the phone company's 820D Data Set. A 150-baud private-line service is provided between the data center and the Billings airport weather bureau office. A KR-33 Teletype provides the weathermen with a hard copy output in one of two formats. The more detailed of the two formats is shown in Figure 3.2. This format identifies the stations, their weather parameter measurement averages, and standard deviations for temperature, wind direction, wind speed, barometric pressure and rainfall accumulation over two different sample sizes. The other format is an abbreviated version and is standardized to normal weather bureau usage.

This weather report is generated automatically each hour, on demand, on a non-interfering basis to the LASA operation. Any LASA computer usage requirement results in a canceled or delayed weather report. The Billings weather bureau chief reports that this weather information has often been used to improve Eastern Montana forecasts as weather fronts moved across the area.

TABLE VI

DATA CENTER EQUIPMENT INCIDENCE OF MAINTENANCE ACTIONS

EQUIPMENT	NUMBER
PDP-7 Computer:	
Mainframe	2
Card reader	1
Typewriter	2
Magnetic tape units	22
360/44 Computer:	
Mainframe	0
Card punch/reader	0
Typewriter	1
Printer	2
Data Adapters:	
IBM Model 1826	0
IBM Model 1827	0
IBM Model 2701	2
Analog System:	
Digital-to analog system	3
Develocorders	1
Maintenance Console and chart recorders	13
Digital System:	
Timing System	1
PLINS	0
Serial Output Unit	0
MINS	0
Misc.	5
Preventive Maintenance:	57
TOTAL	112

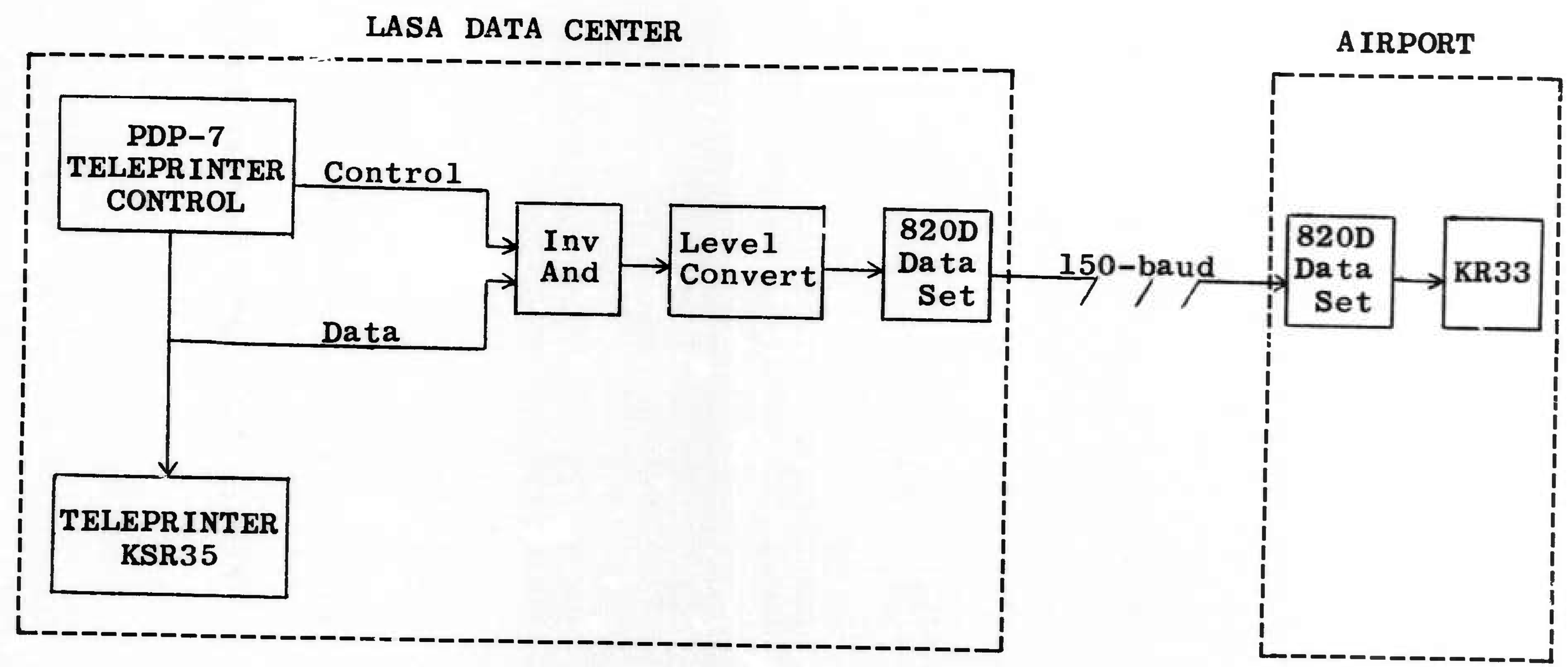

Figure 3.1 LASA/Weather Bureau Interface

140-1400:00.0 LASA WEATHER

SAMP	TEMP DEG F AVE	DEV	DIRECT DEG AZ AVE	DEV	SPEED MPH AVE	DEV	PRES INCH HG AVE	DEV	PRECIP INCH	DEV
AC - ANGELA										
10	50.7	.0	59.2	1.3	.7	.0	25.37	.0	.00	.0
100	50.7	.0	68.4	6.9	.7	.0	25.37	.0	.00	.0
E1 - NAASZ RANCH										
10	49.3	.0	121.6	2.2	7.9	.0				
100	49.3	.0	93.7	19.0	7.5	.4				
E2 - LOCATE										
10	52.8	.0	342.7	1.2	.0	.0				
100	52.8	.0	347.1	4.3	.0	.0				
E4 - CHERRY CREEK RANCH										
10	50.6	.0	123.7	2.8	11.7	.1				
100	50.5	.0	122.3	[illegible].2	11.6	.3				
F1 - LINDSAY										
10	51.3	.0	92.1	.9	3.6	.0				
100	51.3	.0	95.5	2.4	4.0	.2				
F2 - HARDY RANCH										
10	53.1	.0	350.3	1.6	4.2	.0				
100	53.0	.0	352.1	1.0	3.7	.1				
F3 - WILSON RANCH										
10	51.2	.0	175.3	1.8	12.3	.0				
100	51.3	.0	178.5	3.5	11.9	.4				
F4 - JORDAN										
10	50.[illegible]	.0	146.3	2.0	5.8	.0				
100	50.0	.0	149.1	2.7	5.6	.0				

Figure 3.2 LASA Weather Bulletin

3.2 Maintenance Center

3.2.1 General Discussion

The major efforts for this quarter were directed to shop maintenance, training, and special projects discussed in the following paragraphs. Field maintenance was limited to emergency situations during January and February due to travel conditions. Travel conditions improved during the latter part of March, allowing field work to begin at full capacity. Field activity was concentrated on three areas, the ESSA microbarograph and weather station calibrations, RA-5 amplifier exchange, and the long period modification. During this quarter 73 field trips covering 7,743 miles were made by LMC personnel. One trip was made to PMEL at Great Falls, Montana, to pick up calibrated test equipment.

3.2.2 25-Second Calibrator Improvement

The 25-second calibrator card (see Figure 3.3) is used in the PDC drawer of the SEM to filter a .04Hz square wave into a sinusoidal signal for calibration of the long period seismometer system.

The card contains four FET operational amplifiers that were originally produced, using discrete components, at Lincoln Laboratory. The repair of these amplifiers requires matched FET transistors plus discrete component changes to balance the circuit and set the gain.

A commercially available FET operational amplifier, Philbrick/Nexus QFT-5, was tested for interchangeability with the original module. The QFT-5 replaced the original on the card both physically and electrically without any modifications. Testing revealed that gain, dc offset, waveshape and stability were equal to the original circuit. Both the original and the QFT-5 were tested in the environmental chamber over a temperature range of +6° C to +56° C, and there were no measureable differences between the two amplifiers in wave-shape, amplitude, or offset.

The QFT-5 offset tolerances are tight enough that the card trimpots are adequate to set circuit offsets without discrete component changes. Also the QFT-5 can be intermixed with the original type modules on a card. In the future the FET operational amplifier modules that fail will be replaced by the QFT-5 operational amplifier. An additional advantage is that the cost of the QFT-5 is less than the cost of matched Field Effect Transistors.

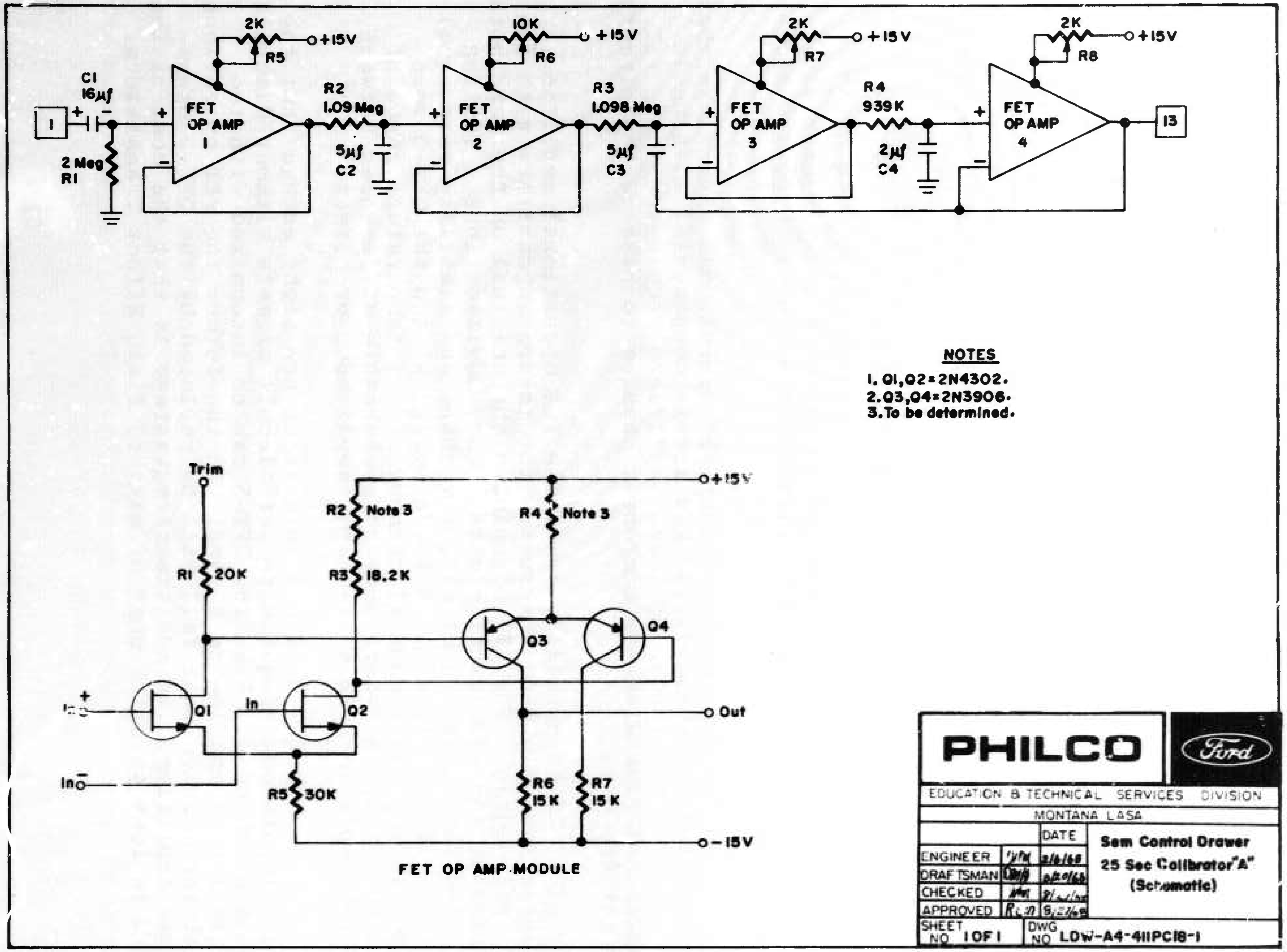

Figure 3.3 25-Second Calibrator A Schematic Diagram

3.3 Array

3.3.1 LP System Cabling and Free-Period Modification

A review of maintenance records for the past eighteen months revealed two major recurring maintenance problems with the Long-Period System. These were malfunctions caused by moisture in the wiring of the LP bunker and the necessity of opening the tanks to readjust the free period. Studies were undertaken concerning these two problems and their solutions. These are discussed separately below.

3.3.1.1 Moisture Problem

The LP vault has inherently a high relative humidity of approximately 98%. The original installation of the vault included an unsealed junction box from which distribution of connecting cables was made to the three individual tanks and associated damping junction assemblies. As temperature changed within the vault, condensation took place and numerous troubles resulted from leakage between wires and ground, and crosstalk between wires. Approximately a year ago an attempt was made to seal the junction box to alleviate the problem, but proved unsuccessful. Leakage still occurred in the cabling and in the junction box. Since July 1969, 36 failures in the LP systems occurred due to this moisture problem.

The solution to this problem has been to eliminate the vault junction box by relocating electrical circuits to the junction box in the Central Terminal Housing. The connection to the tank is then made via two six-pair cables to each tank and interconnections are accomplished at the CTH. These six cables required were already run between the vaults and only required splicing in the LP vault and potting into the tanks. The damping junction assemblies were mounted inside the tanks so that no wiring external to the tanks exists in the LP vault after modification (see Figure 3.4). The tanks were thoroughly dried and the insulation replaced. The tanks were sealed with reactivated silica gel installed. During the modification, the vault was kept dry by the use of a large fabricated blower which lowered the relative humidity to 30%. This was done to prevent trapping any moisture in the tank or subjecting the seismometer to high humidity during the modification. Blocked mass tests were run at the first installation to assure that no system noise was induced by this modification.

3.3.1.2 Free-Period Adjust Problem

Since July 1969, there have been 15 incidents where the free-period adjusting device reached the end of its travel while correcting the free period remotely from the LDC. The only solution to this problem in the past has been to open the tank and manually reset the free period. This is quite undesirable

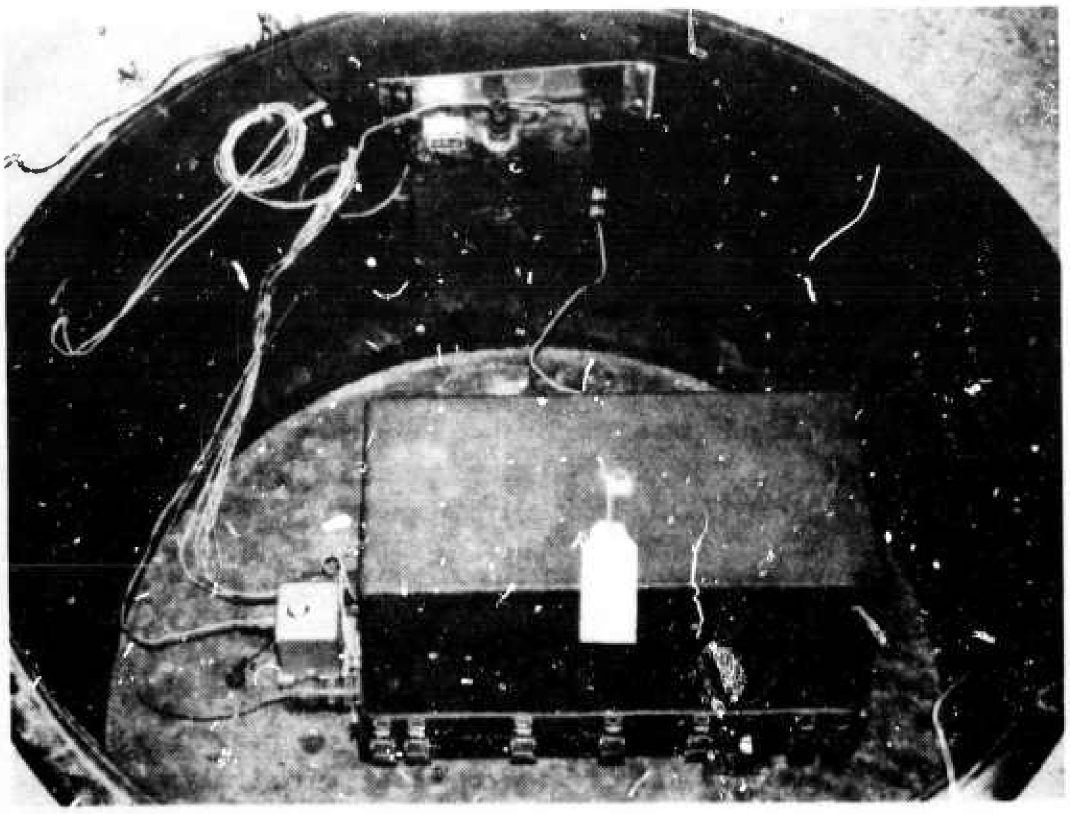

Figure 3.4 Vertical LP Seismometer Installation After Modification

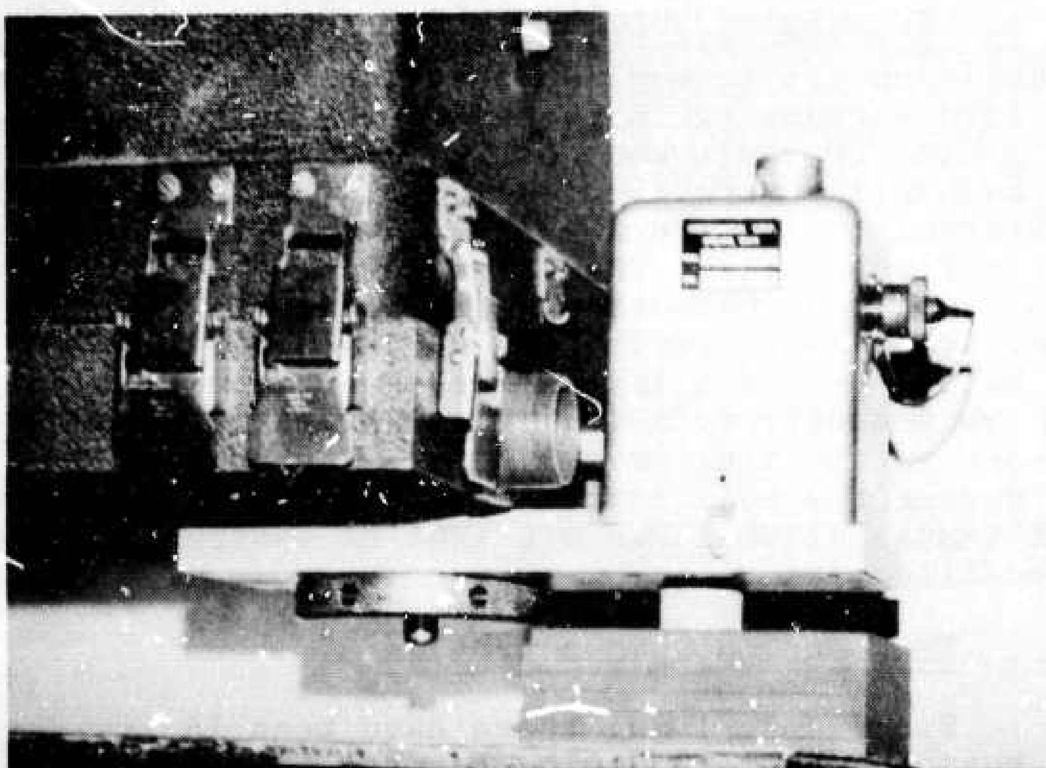

Figure 3.5 Modified Free-Period Remote Adjusting Device Mounting

as it means disturbing the instrument which may require several days to reach stable noise level again.

Records have been kept for the past six months of the free-period drift due to tilting of the LP vault and subsequent corrections. An analysis of these records indicates that the LP vault will tilt with seasonal changes beyond the range of the present free-period adjusting device, depending upon the severity of the seasonal change and the initial setting of the free-period adjusting device. Since these changes have a number of variable factors, it is not deemed predictable.

The solution to this problem has been to increase the range of the free-period adjusting device by a factor of three. This was accomplished by changing the method of mounting the free-period adjusting device. Previously the device was placed under the adjusting foot of the seismometer, and raised and lowered the seismometer at a fulcrum located one-third of the length of the adjusting device. The modified mounting is accomplished by bolting the device directly to the seismometer, eliminating the fulcrum, hence an increase in range by a factor of three (see Figure 3.5). The mounting plate of the adjusting device was strengthened by adding a reinforcing plate to the top, countersunk to allow clearance for the cast shoulder on the horizontal instruments.

A one-month evaluation period was allocated for the first site during which noise levels were recorded prior to and after the modification in reference to other sites. The reinforcing of the mounting plate was a result of this evaluation. An increase in noise level of the vertical instrument in the range of 40 to 60-second periods was noted prior to the reinforcing of the mounting plate. While no evidence of noise was seen on the horizontal instrument, the same mounting technique was employed on them as a preventive measure. Observations of this site have shown no increase in noise level since the final configuration was installed.

3.3.2 RA-5 Amplifier Rehabilitation

Concern for the life of the bias batteries in the RA-5 amplifier was discussed in the First Quarterly Technical Report, October 1969. In order to gain more information on this subject and to determine the overall condition of the amplifiers, all of the amplifiers at subarray C2 were replaced with reconditioned units.

The amplifiers removed from subarray C2 were extensively tested to determine amplifier and battery condition. The testing included checks of detector voltage, gain, dynamic range, feedback bridge range, battery voltage, adjustment settings, polarity, and temperature stability at different gain settings.

The amplifiers with a maintenance history of instability and frequent adjustments were found to have defective components and would fail one or more of the tests. The amplifiers with a clean maintenance history over the past five years passed all of the tests.

Without exception, all of the batteries measured their rated 1.35 volts. Capacity tests were conducted on a sampling of the removed batteries and compared to a new battery. Of those tested, there did not appear to be any decrease in capacity after five years of operation.

As a result of these tests, and after conversations with the manufacturer of the amplifier, we are convinced that the rated shelf life as stated by both the amplifier and battery manufacturers is cautionary. The battery manufacturer's definition of shelf life is based on the total ampere-hour capacity remaining in the battery and not on the voltage potential existing after a given time. It is impossible to predict how long the batteries will last in an RA-5 as there is no current drain (voltage potential being the only operating requirement).

Based on these findings, amplifier rehabilitation will proceed on a limited basis. All amplifiers with a history of instability, frequent adjustment, and/or failure will be replaced at each subarray. These amplifiers will then be repaired, new batteries installed, and tested extensively to insure realiable, stable operation before being used again in the array. This approach will improve the reliability of the array and stagger battery replacements.

3.3.3 Short-Period Sensor Testing

During the exchange of RA-5's at subarray C2, additional checks were made of system parameters. These checks included seismometer natural frequency, seismometer damping ratio, and system frequency response. To obtain a sampling of this data across the entire array, these checks will be continued at all well-head vaults visited for RA-5 replacement. The damping ratio will also be corrected when necessary.

Seismometer natural frequency was measured using the Lissajous method. The distribution of natural frequencies at subarray C2 is plotted in Figure 3.6. A comparison of the results with original installation records indicates that seismometer natural frequencies have decreased an average of .07 Hz. This was substantiated by the fact that damping resistances had to be lowered in all cases where the damping was out of tolerance (overshoot ratio of 15:1 - 22:1). The exact cause of the decrease is unknown but it is suspected to be spring fatigue.

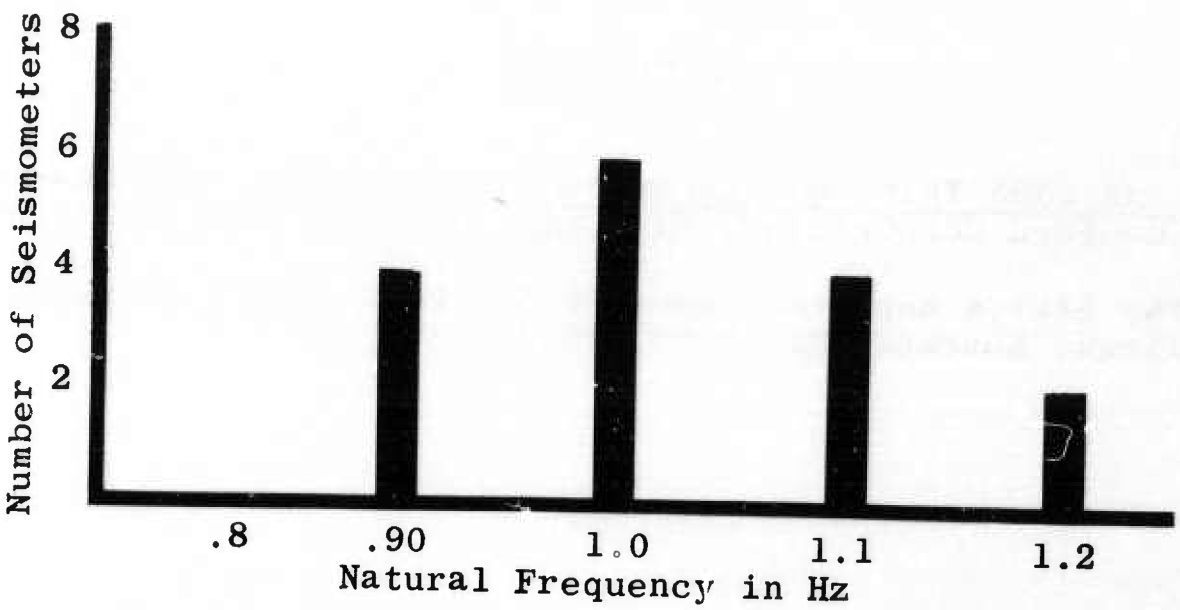

Figure 3.6 Distribution of SP Seismometer Natural Frequencies at Subarray C2

3.3.4 Facilities Support

3.3.4.1 Land Restoration

There have been four incidents of water leakage in the subarray central terminal vaults during this quarter, with three incidents at subarray F1. There was extremely heavy snow cover in that portion of the array this winter. An attempt to landscape the CTH area for better drainage will be started as soon as weather permits. In all cases, because of the effective alarm system, the CTH was reached and cleaned up before damage to the equipment occurred.

A total of four subarrays have been inspected for surficial damage since the winter snows have melted. Restoration of those areas damaged by spring runoff will be started as soon as weather permits.

3.3.4.2 Landowner Contacts

There have been a total of fifteen landowners contacted this period regarding LASA operations and site agreements.

3.3.5 Activities in the Array

There has been no drilling activity within the confines of the LASA complex during this quarter. The status chart for oil drilling activity has been omitted for this quarter but will be updated as drilling activity commences.

REFERENCES

1. Montana LASA Third Quarterly Technical Report, ESD-TR-69-57, Philco-Ford Corporation, Billings, Montana, February 1969.

2. "Array Status Reports" Issue AS-59, Philco-Ford Corporation, Billings, Montana, March 28, 1969.

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13. ABSTRACT

This report concerns the technical activity associated with the operation and maintenance of the Montana Large Aperture Seismic Array (LASA) for the period January - March, 1970. A planned study of the short-period seismic channel tolerances is presented. A new procedure for characterizing array equipment failures is described along with changes to the EDP maintenance documentation system. Recent calibration data for the ESSA microbarograph array are given. Release of a weather bulletin via phone line interface between the LASA Data Center and the Billings Weather Bureau is described. Description of a long-period seismometer cabling and free-period adjustment improvement modification is included. A short-period sensor field test and RA-5 amplifier rehabilitation program in progress is detailed. The LDC computer and array operation statistics are provided.

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